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(54) **Radio / sonic transponder location system**

(57) A radio sonic location system where a central unit Fig 1 sends coded radio signals to three transponders located at predetermined positions $x_1 y_1 \ldots x_3 y_3$. The tranponders, when selected, send out a high frequency audio pulse covering the area that the central unit is located. The central unit measures the elapsed times from the initial radio signal to receiving the audio pulse from the transponders and converts this by computation to distances $d_1 \ldots d_3$. The three distance measurements from three known locations of the transponders are converted by computer 5 to give a positional location $x_4 y_4$ of the central unit in relation to the transponders. By measuring the audio pulse strengths in a set of directional microphones (Fig 4) on the central unit and calculating a proportional strength pattern with the known directional receiving characteristics of the microphones a directional facility of limited accuracy is also available for the central unit in relation to the transponders.

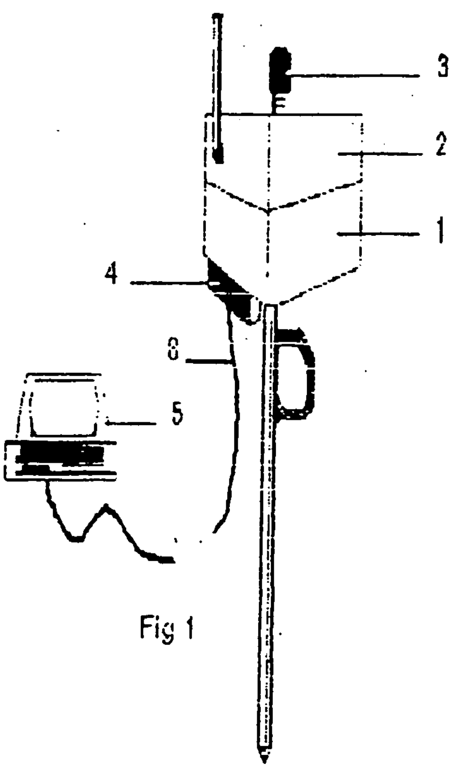
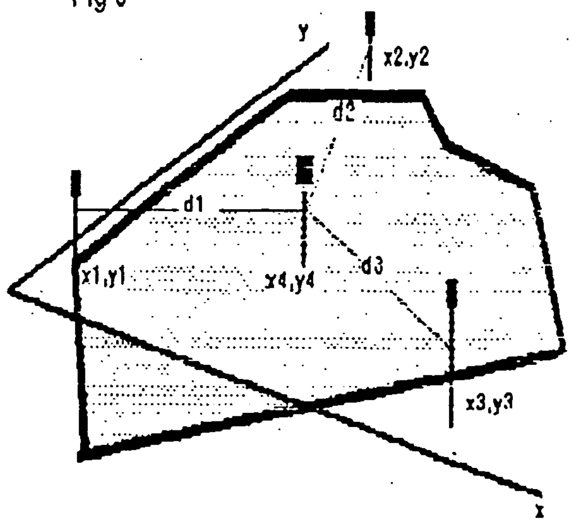



Fig 1

Fig 3

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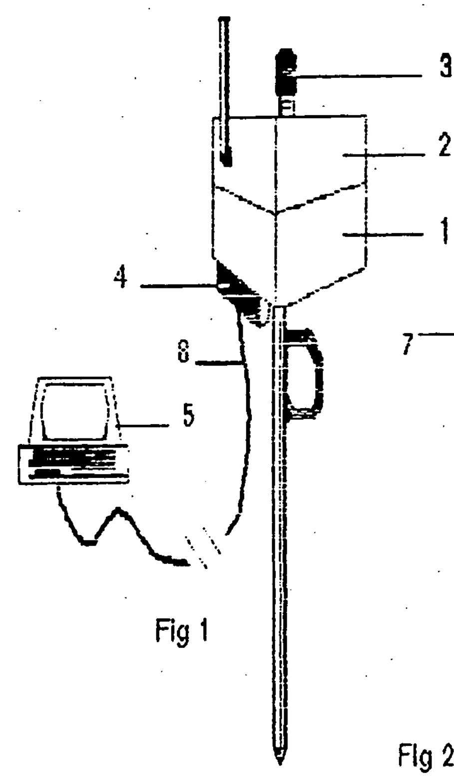



Fig 1

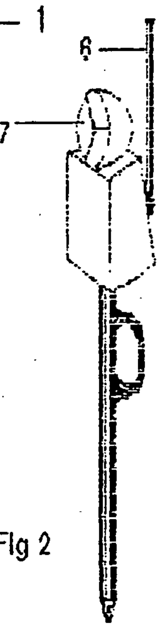
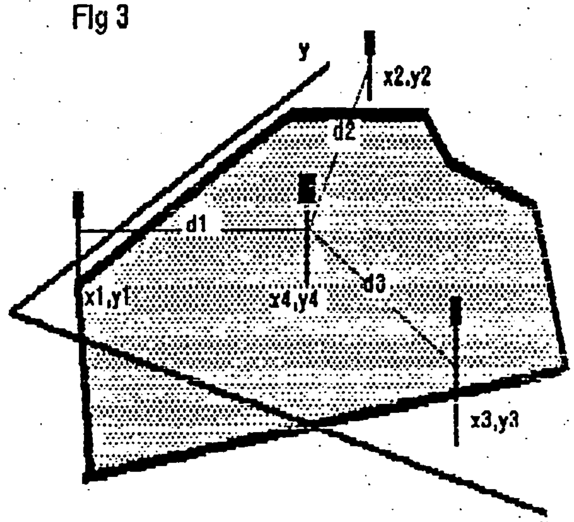



Fig 2

Fig 3



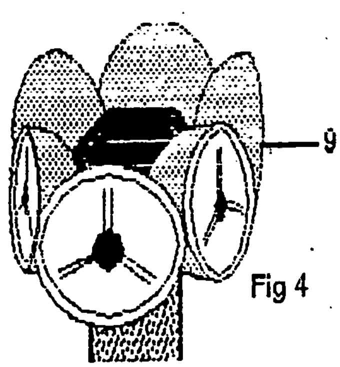




Fig 4

Radio Sonic Location System

The invention relates to a low cost robust measuring system for distance measurements up to a hundred metres in a form suitable for a computer to calculate a location of a position within a pre-determined area. An additional facility of directional orientation of limited accuracy is also available.

The measurement of the location of a position in a pre-determined area with measuring distances of up to a hundred metres is possible with various systems. These range from the simple tape measure to computerised theodolites utilising lazer beams and other directionally sensitive signal receiving devices. However when the position to be located may be continually moving around a predetermined area, accuracy needs to be within a few centimetres and distances data is needed very frequently in a form for computation, the measuring systems available for this range are delicate and expensive.

According to the present invention there is provided a Central unit comprising electronic signal control and time counter unit, low-powered radio transmitter, High Frequency Audio microphone and computer interface connectecting to a computer. The invention also comprises up to three transponders each containing a radio receiver and High Frequency Audio pulse signal generator triggered by a specific coded radio signal sent to its radio receiver by the central unit.
The Central unit transmits a coded radio signal to the transponders located at pre-determined sites.
The transponder sensitive to the particular coded radio signal responds by sending out a High Frequency audio signal pulse, covering the area in which the central unit is located.
The central unit measures the time interval between transmitted coded radio signal and the received audio response, which will be proportional to the distance travelled by the signals. The measurement is repeated for all transponder codes. The code for the transponders and measured time values along with air temperature and pressure measurements are transmitted to a computer through a suitable interface. The computer system is designed to receive this data and convert the time values to distances. With three transponders in pre-determined positions it will be able to calculate the location of the central unit in relation to the transponders.

For additional directional orientation of the central unit in relation to the transponders, the audio signals can be received, instead of by an omni directional microphone, by a matched set of fixed directional microphones, each covering a segment of 360 degrees. The signal strength in each of the microphones is measured and a proportional strength patern of the signal strengths can be calculated and the direction of the signal can be deduced. The accuracy will depend on the narrowness of the arc each microphone can receive at full efficiency, coupled to the characteristics of the fall off in efficiency as its direction to the signal scource varies.

A specific embodiment of the invention will now be described by way of example with reference to the accompanying drawing in which:-

Figure 1 shows in perspective, the central unit with its main components;

Figure 2 shows in perspective, a transponder with its main components;

Figure 3 shows a typical site layout of the three transponders with the central unit at a location being determined;

Figure 4 shows in perspective the alternative set of fixed directional High Frequency Audio microphones.

The central unit Fig 1 consists of an electronic signal control and time counter (1) which is connected to a low powered radio transmitter (2) of similar type as used in radio control for models. The signal control sends out repeatedly in turn to the radio transmitter the three different codes which will each trigger a different transponder unit Fig 2. The transponders receive the coded radio signal via ariel (6) and the transponder sensitive to that coded signal will immediately generate a High Frequency audio pulse in its sender unit (7) aimed to cover the area that the central unit may be positioned in. The signal control starts timing as soon as it sends out the coded signal and measures the elapsed time until it receives the first High frequency audio pulse via the microphone (3). It then selects the next code, after a suitable time for any reflected audio echoes to die out, and repeats the process for the next transponder It holds the elapsed time value for each code until the code is repeated when the time value for that code is then updated. The time values with the associated code are converted to a form that a computer can read by a suitably designed interface (4) for the computer (5) which will be connected to the central unit by a cable (8).
The computer is able to run a straight forward mathematical programme that is able to convert the three elapsed time values into distances compensating for air temperature and pressure values which are also measured on the central unit and passed to the computer via the interface unit. With these three measurements and the known locations of the three transponders, it is able with another straight forward programme to calculate the location of the central unit in relation to the transponders.

For directional orientation of the central unit to the transponders, the microphone is replaced by a set of several fixed directional High Frequency Audio microphones (9) Fig 4 each able to receive the audio signals for a segment of 360 degrees. The signal strengths of the transmitting transponder in each of the microphones are measured in an additional signal control unit where the values and microphone identification are sent to the computer interface. The computer can calculate a proportional strength patern for the microphones and with pre-programmed knowledge of the receiving efficency to direction of the microphones, deduce the direction of the signal in relation to the fixed directional microphones. The directional accuracy of the system will be dependent on the narrowness of the arc that each microphone receives at maximum efficency and the width of arc that it will still receive signals in a gradeable decaying efficiency as its angle to the signal is varied.

## CLAIMS.

Claim 1.
A Radio/Sonic position location system consisting of a Central Unit whose location is to be determined by measuring its distance from three coded radio triggered HF Audio pulse generator transponders placed at predetermined positions. The Central Unit sends coded radio signals to the transponders and measures the elapsed time from emmission of radio signal to receiving HF audio pulse in its microphone from the selected transponder. The elapsed time values associated to each transponder's code and air temperature and pressure measurements sensed on the Central unit or in the area are read by a computer via a suitably designed interface. They are converted with suitable mathematical software to distances and then to a position location of the Central Unit in relation to the known positions of the three transponders.

Claim 2
A Radio/Sonic position location system as claimed in Claim 1 wherein the Central unit consists of a minimum of just a microphone at the position to be located and connected by cable or other means to the remaining units and computer of the Central unit positioned elsewhere.

Claim 3
A Radio/Sonic position location system as claimed in claim 1 or claim 2 but with two transponders in predetermined positions with the position of the Central unit always to one known side of a line joining the positions of the two transponders.

Claim 4
A Radio/Sonic position location system as claimed in any preceeding claim but with the single microphone replaced by a set of fixed directional microphones with additional electronic facilities in the central unit to record signal strengths in each of the microphones and pass this to the computer for calculation of the directional orientation of the microphones to the activated transponder.

Claim 5
A Radio/Sonic position location system as claimed in Claim 4 or as claimed in Claim 2 but working with one transponder.

Claim 6
A Radio/Sonic position location system substantially as described with reference to Figures 1 - 4 of the accompanying drawings.